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Abstract

Full Text

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ASTRONOMY

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ON THE LUMINESCENCE OF THE TWILIGHT SKY IN THE INFRARED REGION OF THE SPECTRUM

(Presented by Academician A. A. Lebedev, 15 V 1957)

The luminescence of the Earth's atmosphere during twilight has been intensively studied for more than 20 years. The comparatively short-lived flash of the yellow sodium doublet at the height of the Earth' s shadow of 40–70 km, discovered in 1936 by V. I. Chernyaev and M. F. Vuks ([1]), and the intense glow of the red line of atomic oxygen, detected in still higher layers by Garrigues ([2]) in the same year, initiated systematic investigations of the phenomenon of twilight luminescence of the atmosphere. Subsequently, the twilight glow of N_2^+ ions (the first negative system), an increase in the intensity of the O_2 bands (λ8669 Å), and OH (λ8431 and 8780 Å) ([3,4]) were detected. In addition, the literature has discussed the possibility of twilight emission of atomic nitrogen λ5200 Å. In 1955 E. D. Shlokhova and M. S. Frish reported ([5]) on the brightness of the twilight sky in the region of 1 μ.

Recently we have obtained data that make it possible to suppose the presence of intense twilight luminescence of a thin atmospheric layer in the infrared region of the spectrum near λ9400 Å, at altitudes of about 35–40 km and about 90–100 km. The luminosity of this layer is most distinctly revealed in the region of the sky located in the vertical of the Sun at an altitude of 20° above the horizon, where the effect of multiple scattering of light is least manifested ([6]). The measurements were carried out with an IKS-3 light filter on an electrophotometer consisting of an oxide-cesium photomultiplier FEU-22 and a direct-current amplifier on a 6S1Zh tube (current amplification $4.1 \cdot 10^4$). The electrophotometer was equipped with an objective 8.9 cm in diameter and with a focal length of 40 cm. A Fabry lens images the aperture of the objective on the photocathode of the multiplier.

Beginning in 1953, while conducting systematic observations of twilight light in the infrared region of the spectrum at the zenith, and later also near the horizon at an altitude of 20°, we accumulated about 100 zenith observations

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Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

and 10 observations at an altitude of 20°. For a qualitative analysis of the observations we represented them in the form of curves of the dependence of the ratio

$$\frac{1}{I}\frac{dI}{dh}$$

(I is brightness) on the height of the effectively scattering layer h. For comparison with our data we constructed the same curve for the dependence of the derivative of brightness on height, using a model of the atmosphere obtained with the aid of rocket data.

Proceeding from the theory of twilight, it is easy to show that a sharply defined luminous layer (luminescing or possessing additional scattering) that actually exists at a certain altitude, because of the great thickness of the twilight ray, will not be sharply manifested on twilight curves. Without additional calculations it is difficult to judge the true dimensions and position of the layer.

If it is assumed that the brightness of the twilight sky is determined only by scat-

scattering of sunlight by air molecules, and if, for the distribution of density with height, one takes the data of the Rocket Panel of the USA (The Rocket Panel) (7), then for the ratio $\frac{1}{I}\frac{dI}{dh}$ one obtains the variation with height (the "normal" curve) shown in Fig. 1 (curve 1). Let us suppose,

Fig. 1

Fig. 2

further, that a layer 10 km thick at an altitude of 60–70 km produces an additional glow equal in brightness to the molecular scattering of sunlight in this layer. The variation of the ratio $\frac{1}{I}\frac{dI}{dh}$, according to our calculations, is given by curve 2 (Fig. 1). Curve 3 corresponds to such a layer at an altitude of 70–80 km. From the course of the curves it is seen that the new curve with a luminescing layer intersects the normal curve at the height at which the layer is located, while the influence of the layer already begins at 35 km and continues up to 90 km.

Consideration of the observational material (as an example, three curves are given—Fig. 2) makes it possible to draw the following conclusions. There are

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Fig. 3

Figure 3: Fig. 3

Fig. 4

Figure 4: Fig. 4

two layers—at an altitude of about 35-40 km and about 90-100 km. On nine curves out of ten (at $z = 70^{\circ}$) both layers are present, and only on one curve is the first layer absent. The layer at about 90-100 km is less stable than the layer at about 35-40 km; its height varies within ± 20 km.

It must be pointed out that analogous curves of $\frac{1}{I}\frac{dI}{dh}$, obtained in other parts of the spectrum (λ_{max}5270 Å, λ_{max}3790 Å), do not reveal these layers, which makes it possible to ascribe this phenomenon to luminescence rather than to dust particles. Figure 3 gives the data of simultaneous observations in two regions of the spectrum (at $z = 70^{\circ}$). It should be especially noted that the lower layer at about 35-40 km is, apparently, the layer discovered by E. D. Sholokhova and M. S. Frish from observations in 1954 at Lagodekhi and Abastumani.

The maxima on the curves obtained at $z = 70^{\circ}$ are expressed more distinctly than in zenith observations, which is apparently explained by the greater influence of secondary scattering of light in the zenith (Fig. 4). Of 50 curves obtained in the zenith, these layers are revealed on 37 curves, whereas

in observations near the horizon they were almost always observed. The form of the curves shows that the layer at about 35-40 km is more powerful than that at about 90-100 km.

Fig. 3

Fig. 4

In conclusion, I express my sincere gratitude to Prof. I. A. Khvostikov for discussion of the results and valuable advice.

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